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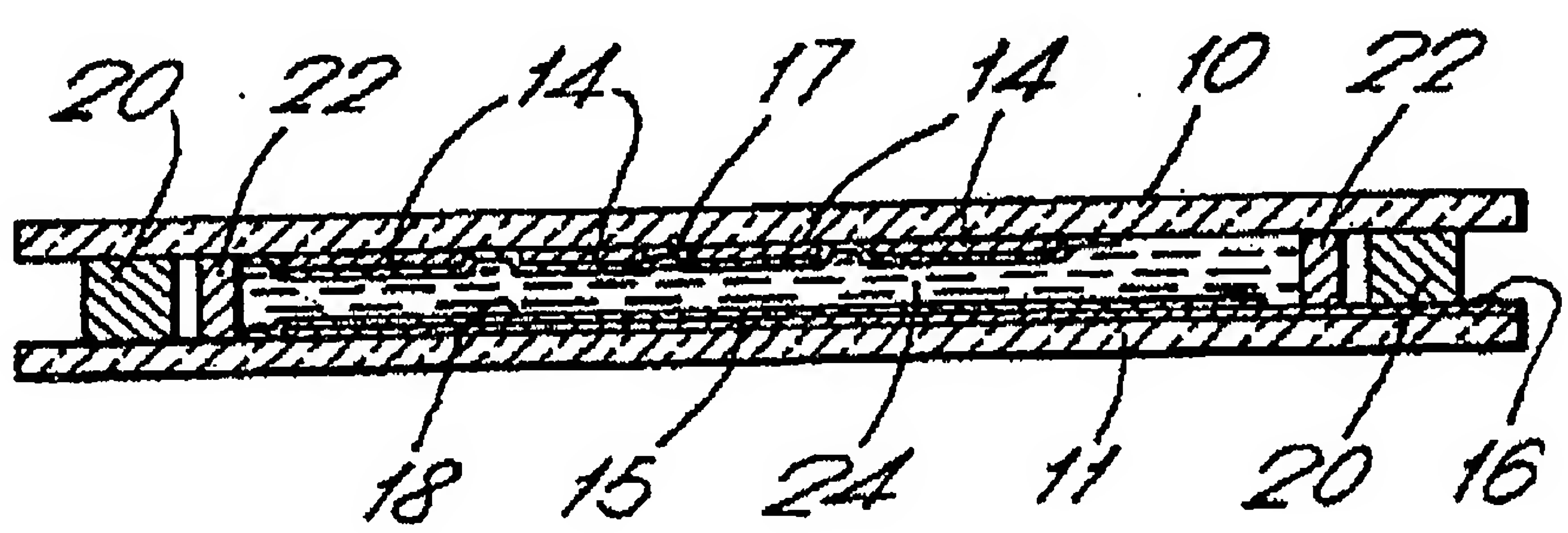
(54) Liquid crystal display device

(57) A liquid crystal display device has a spaced pair of electrode-carrying substrates (10, 11) with a layer of liquid crystal material (24) therebetween in a display area and joined by a peripheral sealing frame (20) of expoxy adhesive. To avoid possible contamination of the liquid crystal material either by epoxy of the frame or by contaminants permeating therethrough, a barrier wall (22) a polyimide is disposed alongside the sealing frame over at least a major part of its length and extends between the two substrates to separate the liquid crystal material in the display area from that part of the frame.

Fig.1.



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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

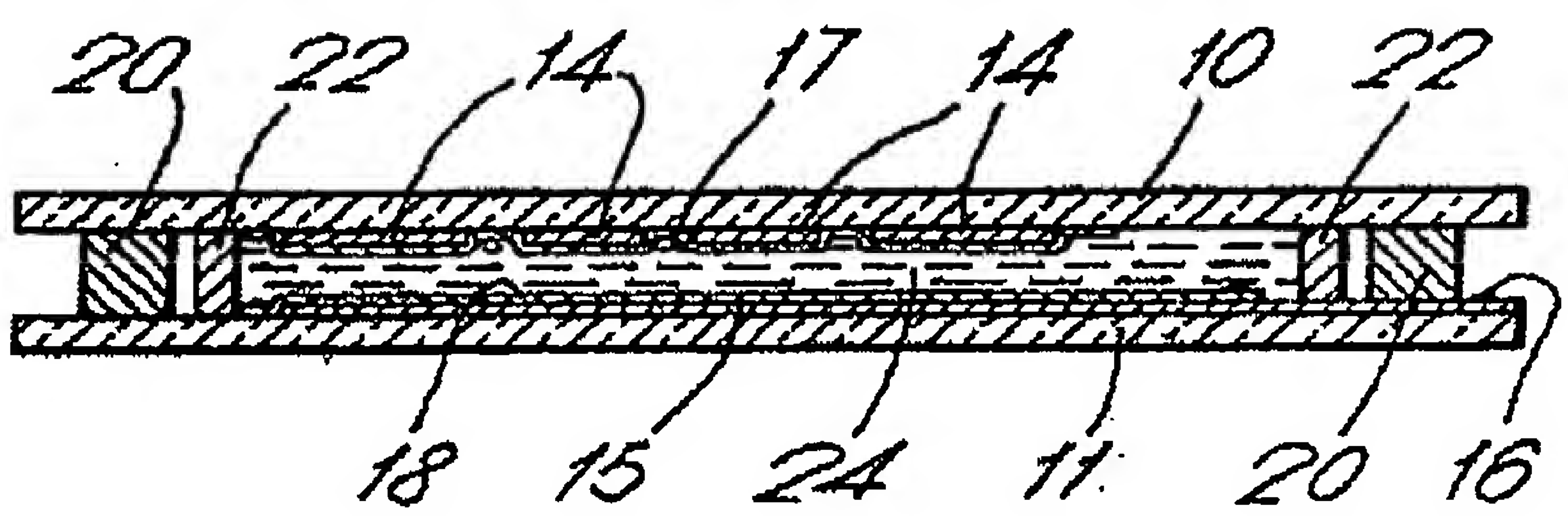
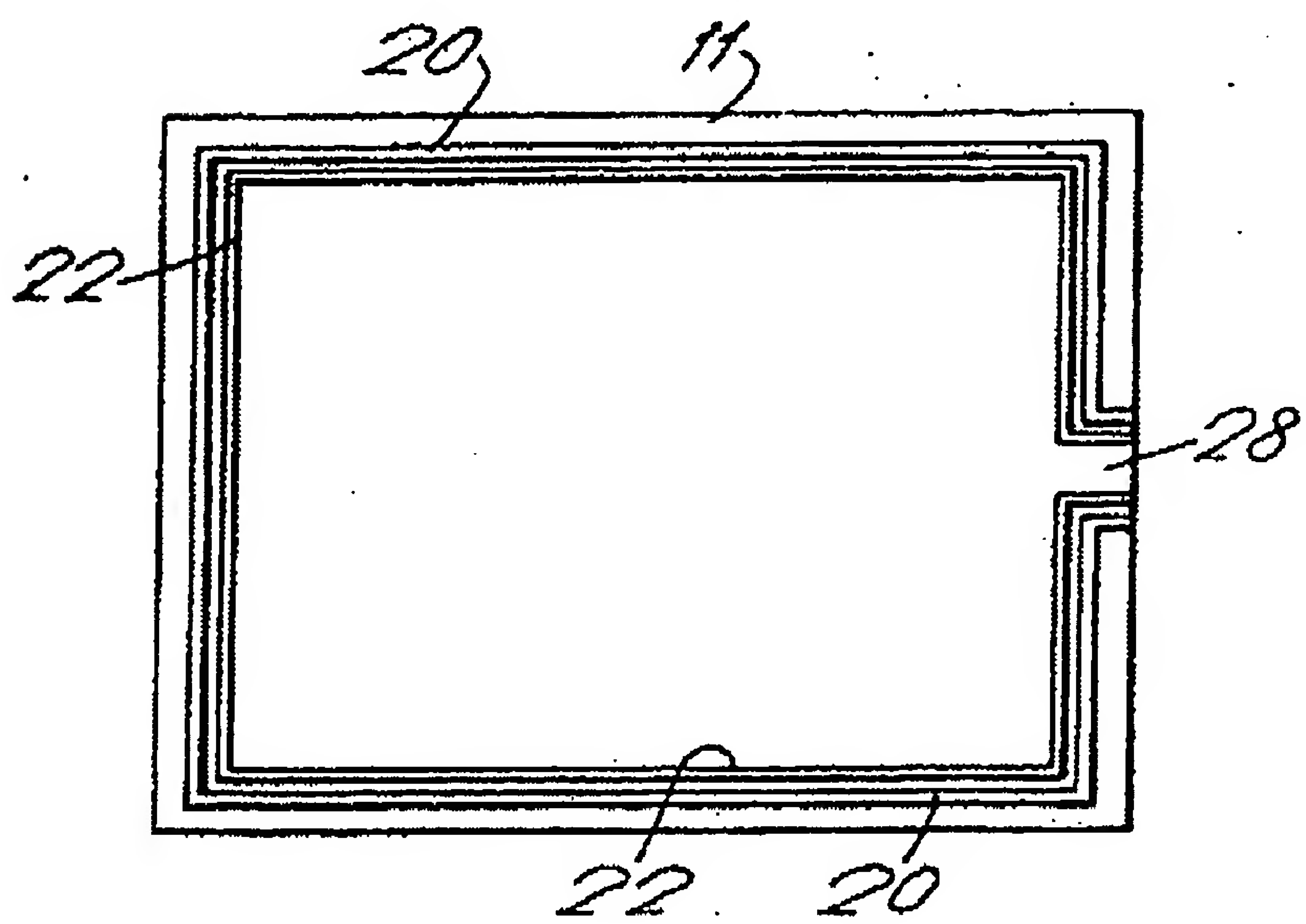


Fig.2.



SPECIFICATION

Liquid crystal display devices

This invention relates to a liquid crystal display device comprising a pair of substrates with a layer of liquid crystal material disposed therebetween and a peripheral sealing frame of epoxy extending between the substrates and around the liquid crystal material.

Such a device may be used to display alphanumeric or pictoral information by applying appropriately configured energising electrodes to the surfaces of the substrates adjacent the liquid crystal layer. In addition to providing a sealing function, the epoxy frame serves also to bond the substrates together and, together with spacing elements dispersed therein, may also act to maintain a predetermined spacing between the substrates.

The use of epoxy for this purpose is common as the epoxy material is relatively cheap and easy to apply. An example of suitable epoxy material which has been used heretofore is the single component epoxy sold under the name Grilonite (Trade Mark) PK 60703. However, it has been found that sealing frames constituted by epoxy can be disadvantageous as, over a period of time, epoxy may dissolve slowly into the organic liquid crystal material to contaminate the liquid crystal material whereby the resistivity of the liquid crystal material is altered, thus affecting display performance. The effect of dissolved epoxy may not be unduly troublesome in a low resistivity kind of display device, but in a high resistivity kind of device the effect becomes significant. Moreover, epoxy sealing frames may sometimes also permit water from ambient atmosphere to permeate therethrough, albeit slowly, again resulting in contamination of the liquid crystal material through the formation of bubbles.

The use of epoxy sealing frames may therefore be a major contributory cause in limiting the display device's lifetime.

In order to avoid this problem, it is known to use in liquid crystal display devices sealing frames formed of glass frit rather than epoxy. Whilst these frames are found to be generally satisfactory in maintaining the liquid crystal material free from contamination, their fabrication involves a high temperature (around 350 to 600°C) processing operation and thus they are more complicated and more expensive to apply than epoxy frames.

It is an object of the present invention to provide a liquid crystal display device having for convenience a sealing frame of epoxy but which at least to some extent overcomes the aforementioned problems with known kinds of devices.

According to the present invention, there is provided a liquid crystal display device comprising a pair of substrates with a layer of liquid crystal material disposed therebetween in a display area and a peripheral sealing frame of epoxy extending between the substrates and around the liquid crystal material, which is characterised in that a barrier wall comprising polyimide material extends adjacent at least a major part of the length of the sealing frame and substantially separates the liquid crystal material in the display area therefrom.

Thus, the display device retains an epoxy sealing frame and as a result shares the advantages associated with the use of this material. However, with such a device, the liquid crystal material in the main display area is physically impeded from contacting at least a major part of the epoxy frame by the barrier wall, so that contamination of the liquid crystal material by that part, and by water permeating through that part, is avoided. The polyimide barrier wall itself is substantially non-contaminating. Whilst the liquid crystal material could be completely confined by the polyimide barrier wall to prevent any contamination by the epoxy sealing frame, this need not be essential. Because the extent of contamination is directly proportional to the area of contact between the liquid crystal material and the epoxy sealing frame, any reduction in that contact area results proportionately in a corresponding reduction in the extent of contamination. Hence if, say, only three-quarters of the length of the epoxy sealing frame is shielded by the barrier wall from the liquid crystal material, a significant reduction in contamination and its effect is nevertheless achieved. For example, in the case of a generally rectangular display device in which the sealing frame is also generally rectangular, the barrier wall may be present to prevent contact between the liquid crystal material contained within that generally rectangular boundary and three sides of the sealing frame, this being sufficient to reduce contamination to an acceptable level even for a device intended to be operated over a prolonged period of time. In a preferred embodiment, the barrier wall extends alongside the at least major part of the length of the sealing fame and is in the form of a continuous strip, as is the sealing frame. Such a barrier wall may conveniently be provided as a screen-printed strip or by spinning a layer of polyimide precursor and removing unwanted regions to leave a strip of polyimide.

The barrier wall may be disposed abutting the at least major part of the length of the sealing frame or alternatively spaced slightly therefrom.

Preferably, the barrier wall extends completely between the two substrates over the said at least major part of the length of the sealing frame. This ensures separation of the liquid crystal material from that part of the sealing frame. However, in the case where the barrier wall is spaced slightly from the sealing

frame, contamination of the liquid crystal material in the main display area within the barrier wall is still considerably reduced even if a small gap exists between the barrier wall and one of the substrates. During filling of the device, liquid crystal material will also fill the space between the barrier wall and the sealing frame through this gap. Although the liquid crystal material in the gap will then become contaminated over a period of time, the flow properties of the material and the effect of the barrier wall are such that a much greater period of time will pass before an amount of contaminated material sufficient to cause any significant effect on the performance of the device is actually present in the main display area.

In order to improve the frame's sealing properties and reduce the possibility of water (and other undesired contaminating materials) permeating through the sealing frame, an inert, electrically insulative powder such as silica or alumina powder may be mixed with the epoxy. This has the effect of rendering the sealing frame substantially impervious.

Spacing elements may be dispersed in the barrier wall to maintain a predetermined spacing between the two substrates.

A liquid crystal display device in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a schematic cross-sectional view through the display device; and

Figure 2 is a schematic plan view of a part of the display device during fabrication showing the layout of certain components on one substrate of the display device.

Referring to Figure 1, the liquid crystal display device comprises two parallel glass supporting plates 10 and 11. A pattern of transparent electrodes 14 to be driven individually is provided on the supporting plate 10 which are connected through supply electrodes to external connection eletrodes (not shown) in conventional manner. An opposite continuous second electrode 15 which is common for the pattern of electrodes 14 is provided on the supporting plate 11 and extends over a greater part of that plate. Alternatively a number of discrete area second electrodes electrically interconnected through narrow strip portions and in registration with respective ones of the electrodes 14 may instead be used. The electrode 15 is connected to an external connection electrode 16.

The pattern of electrodes 14 may be in the form of alpha-numeric characters or pictoral representations depending on the purpose for which the display device is intended to be used. The electrodes 14 and 15 may for example be of indium tin oxide.

The electrodes 14 and 15 and exposed areas of the supporting plates 10 and 11 adjacent thereto are covered by continuous liquid crystal orientation layers 17 and 18 comprising an organic polymer, for example polyimide. These layers 17 and 18 may extend (as shown in Figure 1) only over a central region of the plates 10 and 11, or alternatively may extend completely across the plates 10 and 11. The plates 10 and 11 together with their associated electrodes and orientation layers constitute substrates of the device.

The two supporting plates 10 and 11 are bonded together and sealed peripherally by a frame 20 comprising a continuous strip of suitable epoxy adhesive such as Grilonite PK 60703 (Trade Name), mixed with alumina particles extending between the plates 10 and 11 (and over the orientation layers 17 and 18 if these are formed completely over the plates 10 and 11) to define a containment volume (cell) for liquid crystal material. Besides bonding together and sealing the plates 10 and 11, the frame 20 can serve when used together with spacing elements dispersed therein also to space the plates 10 and 11 apart. To maintain a predetermined and accurate spacing relationship, particularly in the case of large area matrix display devices, the device may further include grains (not shown) or other spacing elements, for example, fibres, distributed homogeneously within the containment volume and abutting the two substrates.

Disposed slightly inwardly of and alongside the frame 20 and extending completely between the plates 10 and 11 is a barrier wall 22 of polyimide material, namely Pyralin (Trade Name) PI 2550. This barrier wall 22 may extend completely around the periphery of the device, parallel to the sealing frame 20. However a small opening may perhaps be provided along the length of both the barrier wall and sealing frame to permit the introduction of liquid crystal material.

The space between the two substrates, constituting the device's display area, is filled with nematic liquid crystal material 24 having positive dielectric anisotropy, for example liquid crystal material available from Messrs. BDH under the name of E7. Upon the application of potentials to certain combinations of electrodes 14 and 15 and the creation thereby of an electric field across the liquid crystal, desired information can be displayed in known manner, polarisers (not shown) being provided on the outer surfaces of the plates 10 and 11 for this purpose. Different liquid crystal materials exhibiting other electro-optical effects may be employed however, for example dynamic scattering, guest-host cholesteric, and electrically induced birefringence effect materials. Apart from the provision of the barrier wall, the display device is of a type generally well known and a detailed description of its construction and operation is for this reason considered unnecessary.

Referring to Figure 2, there is shown a schematic plan view illustrating the lay-out of

the sealing frame 20 and barrier wall 22 on one substrate of the device during fabrication. In this particular case, the sealing frame 20 defines a generally square containment volume, i.e. cell. For simplicity the electrode 15 configuration, supply conductors and orientation layer 18 have been omitted from the figure. As can be seen, the frame 20 of epoxy material with alumina extends substantially continuously around the periphery of the plate 11 and defines along one side an opening 28 through which liquid crystal material is eventually to be introduced. The barrier wall 22 of polyimide extends substantially continuously adjacent to and within the frame 20 around the periphery of the plate 11 and at the opening 28. Following assembly of the other substrate and the introduction of liquid crystal material, the opening 28 is sealed. In this way, the layer 24 of liquid crystal material in the display area is totally confined by the barrier wall 22 and prevented from physically contacting the frame 20. Thus, whilst the advantages of using epoxy material for the frame 20 are retained, the disadvantages associated with this material are avoided since contamination of the liquid crystal material by the epoxy of the frame 20, and possibly also by permeation of water through the frame 20, cannot occur. The polyimide of the barrier wall is substantially non-contaminating in this respect and substantially impermeable by water.

Spacing elements for maintaining a desired separation of the two substrates may be embedded in the barrier wall 22.

The opening 28 may be omitted and liquid crystal material instead introduced through an aperture provided in the plate 11. In this case, the sealing frame 20 and the barrier wall 22 would both be non-ending.

Whilst shown slightly spaced from the frame 20, the barrier wall 22 may be arranged such that following assembly of the plate 10 thereon, and allowing for a certain amount of flow of the epoxy frame 20, it abuts the frame 20 so as to minimise the reduction in area of the liquid crystal layer 24 caused by the presence of the barrier wall 22.

It is not necessary that the barrier wall 22 completely surrounds and confines the liquid crystal layer 24 in the main display area. As the extent of contamination of liquid crystal material in this area by epoxy material is dependent mainly on the extent of area contact therebetween, a display device in which the level of possible contamination is reduced to a sufficiently low value where it becomes insignificant and acceptable for most purposes can be produced by arranging the barrier wall to shield the liquid crystal material from a major part of the epoxy frame 20 rather than all of the frame 20 as described above. For example, with regard to the arrangement of Figure 2, the upper and lower sides of the barrier wall may continue right up to the side of the frame 20 containing the opening 28 and terminate at those points so that the aforementioned side of the frame 20 is exposed to and allowed to contact the liquid crystal material. Obviously, the barrier wall 22 terminates and contacts that side of the frame 20 in such a manner as to provide a seal to prevent liquid crystal material from entering the gap (if provided) between the barrier wall 22 and frame 20. Although therefore in this arrangement, the liquid crystal material is in contact with a part of the epoxy frame 20, a major part of the frame 20 is still shielded by the barrier wall so that the amount of contact actually existing, and hence the correspondingly proportionate amount of contamination likely to be caused, is relatively small and, in many cases within acceptable limits.

The fabrication of the display device will now be described briefly. The patterned electrode 14 of indium tin oxide is laid down on the supporting glass plate 10 in the desired configuration together with its associated supply electrodes and connection terminals using any convenient known technique such as vapour deposition, sputtering or silk screening, to a thickness of around 0.15μm. The continuous electrode 15, again with its associated supply electrode and connection terminal, is deposited on the glass plate 11 in similar manner.

Polyimide precursor such as polyamic acid, eventually forming the polyimide barrier wall 22, is then provided on the plate 11 using a screen printing technique. Alternatively polyimide precursor may be spun onto the plate 11 to a required thickness and thereafter unwanted regions of the material removed to leave the desired pattern. In either case, the polyimide precursor is applied in liquid form in a volatile solvent, for example methanol. Following its application on the plate 11, and the selected removal of unwanted regions if necessary, the polyimide precursor is cured by subjecting the plate 11 to a temperature up to 240°C for approximately 1 hour to obtain a continuous strip of substantially uniform height equal approximately to the desired cell spacing, say 12μm and around 3mm width, although the width chosen is not critical.

The orientation layers 17 and 18 are then formed by depositing layers over the exposed surface areas of the electrodes 14 and 15, and plates 10 and 11 to a thickness of around 0.1μm in conventional manner.

The frame 20 is formed as a screen printed strip of partly cured epoxy mixed with alumina particles acting a filler. The strip is deposited such that, after preliminary drying, it has a thickness (i.e. height) of, say, around 22μm and a width of 0.5 to 1.2mm). The strip may also contain spacing elements, for example, grains of glass or alumina. Additional spacing elements may be located in the liquid crystal containment volume. The plates 10 and 11

are then brought together under pressure whereupon the epoxy strip is compressed, allowance being made in the device construction for the inward creep of epoxy as a result of this, until the desired plate spacing determined by spacing elements if provided, of, in this particular case, around 11μm is achieved. In so doing, the plate 10 is forced against the polyimide strip constituting the barrier wall and compresses that strip very slightly so that a fluid-tight seal is achieved.

Thereafter, the structure is heated up to 170°C to effect final curing of the epoxy strip to bond and seal the plates together.

Finally, liquid crystal material is introduced through either the opening 28, or alternatively an aperture in one of the plates as previously mentioned, under vacuum to fill the volume defined by the barrier wall 22, and exposed parts of the frame 20 if present, the opening thereafter being sealed by an epoxy plug.

CLAIMS

1. A liquid crystal display device comprising a pair of substrates with a layer of liquid crystal material disposed therebetween in a display area and a peripheral sealing frame of epoxy extending between the substrates and around the liquid crystal material, characterised in that a barrier wall comprising polyimide material extends adjacent at least a major part of the length of the sealing frame and substantially separates the liquid crystal material in the display area therefrom.

2. A liquid crystal display device according to Claim 1, characterised in that the barrier wall extends alongside the at least major part of the length of the sealing frame and is of continuous strip form.

3. A liquid crystal display device according to Claim 1 or Claim 2, characterised in that the barrier wall is formed by screen printing.

4. A liquid crystal display device according to Claim 1 or Claim 2, characterised in that the barrier wall is formed by spinning a layer of polyimide precursor over one of the substrates and removing unwanted regions to leave a strip of polyimide.

5. A liquid crystal display device according to any one of the preceding claims, characterised in that the barrier wall extends completely between the two substrates over the said at least major part of the length of the sealing frame.

6. A liquid crystal display device according to any one of the preceding claims, characterised in that the sealing frame comprises an inert, electrically insulative, powder mixed with epoxy.

7. A liquid crystal display device according to any one of the preceding claims, characterised in that spacing elements are dispersed in the barrier wall to maintain a predetermined spacing between the two substrates.

8. A liquid crystal display device substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

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